

This is an excerpt from



## **Air Force Office of Scientific Research Broad Agency Announcement 2005-1**

Ongoing Until Superseded. Download date: July 13, 2005.

Documents of this kind are always subject to revision. For this reason, before preparing and submitting a proposal, always confirm that your source document is still current and make certain to obtain any subsequent modifications or appendices. Upon request, our office would be pleased to help you in this regard.

Tom Murphy  
Office of Intellectual Property & Sponsored Research  
Brookhaven National Laboratory  
Extension 3312  
E-mail: [tmurphy@bnl.gov](mailto:tmurphy@bnl.gov)

## **Physics and Electronics**

Research in physics and electronics generates the fundamental knowledge needed to advance Air Force operational capabilities in directed energy weapons; surveillance; stealth; electronic countermeasures; guidance and control; information and signal processing; and communications, command, and control. The program is of substantial breadth, extending from plasma and quantum physics, to the understanding of the performance of novel electronic devices, to maintaining device integrity in the harsh environment of space, to engineering issues such as those found in microwave or photonic systems or materials-processing techniques. One main objective of the program is to balance innovative science and Air Force relevance, the first element being forward looking and the second being dependent on the current state of the art. This directorate takes particular pride in the strong synergistic ties it has forged between university researchers and those in the Air Force Research Laboratory community. Research areas of interest to the Air Force program managers are described in detail in the subareas below.

### **ElectroEnergetic Physics**

This Air Force program seeks innovative approaches and novel concepts that efficiently drive or cleverly exploit the collective interactions of charged particles with electromagnetic fields or the effects of resultant plasmas on their surroundings. Our primary interests currently encompass ideas for advancing the state-of-the-art in the following areas: electron-beam-driven sources of microwave and millimeter-wave radiation (high power microwaves (HPM) and/or vacuum electronics), compact pulsed power, particle-beam physics, plasma/pulsed-power/radio frequency (RF) bio-effects, next-generation combat simulation, power-efficient methods to generate and maintain significant free-electron densities in sea-level air, as well as particle-beam-related micro- and/or nano-device concepts.

Proposals for new compact pulsed power research must show technical linkage to this office's ongoing DoD FY01 Multidisciplinary University Research Initiative (MURI)<sup>1</sup> program on "Compact, Portable Pulsed Power." They should also relate to pulsed power efforts underway at Air Force and other defense laboratories (See Section V for a description of MURIs).

Research in the e-beam-generated microwave source area will address Air Force needs for communications, surveillance, electronics countermeasures, and/or directed energy weapons systems. New efforts should be synergistic with the ongoing FY99 "Innovative Vacuum Electronics" MURI and/or with the military's HPM research program.

Of particular interest, would be new ideas for micro-scale or nano-scale plasma and/or vacuum electronics device concepts. This does not include field-emitter area (FEA) research. Specifically, MEMS concepts that could be applied to a sensor/actuator system for a future "smart" microwave tube would be exceptionally interesting.

Of course, fresh ideas for completely new plasma-, vacuum-electronics-, or pulsed-power-related research areas are always of interest as long as Air Force relevance can be postulated. However, in general, this program is not interested in dense (strongly-coupled) plasmas, fusion plasmas, or space plasmas, since those topics are the subjects of focus for other agencies.

Dr. Robert J. Barker AFOSR/NE (703) 696-8574  
DSN 426-8574 FAX (703) 696-8481

E-Mail: [robert.barker@afosr.af.mil](mailto:robert.barker@afosr.af.mil)

### **Space Electronics, University NanoSatellites**

This research program stresses Air Force requirements for advanced high performance electronic materials and devices. Depending upon the specific requirement, this calls for various combinations of higher efficiency, higher speed, higher power, lower noise, lower voltage/lower power performance and so forth. [It is useful for the proposer to learn of these Air Force needs and to point out how the ideas being put forward would address them.] There is greater emphasis given to analog devices than to digital and optoelectronic structures, which are covered in other programs at AFOSR and elsewhere in the DoD. Emphasis is shifting away from more 'traditional' compound semiconductor materials, such as GaAs and InP, to emerging materials such as the wide bandgap GaN family. Likewise, SiC materials and devices are not featured due to adequate coverage at other agencies such as DARPA and ONR. A particular interest is nitride-based electronic devices capable of high temperature operation, high RF power output and/or power density, high power-added efficiency and low noise figure. Effective electrical and environmental passivation of such devices is important as are other factors affecting device reliability and stability. Elimination of electronic dispersion in these devices remains an important challenge.

Proposals should avoid duplication of efforts at DARPA/MTO. However, convincing plans of working in coordination with this major program are regarded as positive proposal components. An emerging interest is that of materials and devices enabling 'reconfigurable' electronics. The objectives here are to devise electronic systems and circuits capable of operational flexibility and graceful degradation.

Dr. Gerald L. Witt AFOSR/NE (703) 696-8571  
DSN 426-8571 FAX (703) 696-8481  
E-Mail: [gerald.witt@afosr.af.mil](mailto:gerald.witt@afosr.af.mil)

### **Atomic and Molecular Physics**

This program involves experimental and theoretical research on the properties and interactions of atoms and molecules. Atomic and molecular interactions with electromagnetic radiation and gravitational fields form the basic underpinning of a large range of technical applications addressing current and future Air Force needs. These include timekeeping, navigational guidance, remote sensing, secure communications, and atmospheric physics. Traditional Air Force efforts also include research in low- and high-altitude nuclear weapons effects, directed energy weaponry, and lasing mechanisms.

Specific research topics of interest include:

- Studies of the overlap between atomic and condensed matter physics – particularly the usage of atomic physics to learn about many-body phenomena
- The evolution of cold atomic systems into ultralow-density condensed matter systems
- The interaction of atoms and molecules with strong fields
- Cooling and trapping techniques applied to a broad range of problems, including high-resolution spectroscopy and cold atom collisions—particularly between atoms in excited quantum states.
- High-precision techniques for navigation, guidance, and remote sensing—particularly those suited to use in an orbital environment.
- The formation and evolution of cold ( $<1$  K) plasmas.
- The dynamics of single, large molecules in complex systems.

- Antiproton capture, confinement, transport, injection, and annihilation processes—particularly those leading to the formation and storage of anti-hydrogen.
- Novel techniques for production of high-power microwaves, X-rays, and gamma rays.
- Cross-sections of atmospheric species.

Dr. Anne Matsuura AFOSR/NE (703) 696-6204  
 DSN 426-6204 FAX (703) 696-8481  
 E-Mail: [anne.matsuura@afosr.af.mil](mailto:anne.matsuura@afosr.af.mil)

## **Remote Sensing and Imaging**

This program investigates fundamental issues concerning remote sensing, including propagation and image formation processes. Topics include, but are not limited to:

- Remote sensing signatures and backgrounds, particularly sensing from space and observations of space objects from the ground, and the sensing of difficult targets such as targets under foliage, buried targets, etc.
- Enhancement of remote sensing capabilities, including novel solutions to system limitations such as limited aperture size, imperfections in the optics, and irregularities in the optical path.
- Theoretical foundations for imaging diversity methods (e.g., wavelength diversity, phase diversity, polarization diversity).
- Information-theoretic approaches to the general problem of unique image recovery from limited information about the object. Quantitative measures of convergence of deconvolution algorithms, estimates of tolerable noise in the reconstruction process, and number of iterations required to provide the "best" reconstructed image.
- Rigorous scattering models to describe the spectral and polarimetric signature from targets of interest using basic material physical properties with the goal of providing better understanding of the physics of the reflection or emission and the instrumentation requirements for next generation space surveillance systems.
- Propagation of coherent and incoherent electromagnetic energy through a turbulent atmosphere, including laser propagation for energy transport, imaging, and communication.

Dr. Kent Miller AFOSR/NE (703) 696-8573  
 DSN 426-8573 FAX (703) 696-8481  
 E-mail: [kent.miller@afosr.af.mil](mailto:kent.miller@afosr.af.mil)

## **Optoelectronics: Components and Information Processing**

The current primary program thrusts include investigations in two affiliated areas: (1) the development of optoelectronic devices and supportive materials, and (2) the insertion of these components into optoelectronic computational and information-processing systems. Device exploration and architectural development for processors are coordinated; synergistic interaction of these areas is expected, both in structuring architectural designs to reflect advancing device capabilities and in focusing device enhancements according to system needs.

Research in optical materials and optoelectronic devices emphasizes the insertion of optical technologies into computing, image-processing, and signal-processing systems. To this end, this program continues to foster surface-normal interconnection capabilities, combining arrays of sources or modulators with arrays of detectors, with both being coupled to local electronic processors, often in "smart pixel" configurations. Understanding the fundamental limits of the interaction of light with matter is important for achieving these device characteristics.

Semiconductor materials and structures are the basis for the smart pixel and related device technologies. Numerous device approaches are part of the program as are techniques for optoelectronic integration.

System-level investigations incorporate these devices into processing architectures that exploit their demonstrated and envisioned attributes and determine appropriate problem classes for optical and optoelectronic approaches. The computational advantages and proper use of parallelism provided by optical implementations continue to guide architecture development. Computer interconnections continue to encounter increasing difficulty in signal transmission constrained by wire-crossing layout restrictions, electromagnetic interference, and cross-talk--impediments that may be circumvented by optical interconnect approaches. Alternatively, another program thrust emphasizes the use of the inherent, extremely high bandwidth of optical carriers by investigating systems that use multispectral data representations.

Fabrication of optical structures has now evolved to a precision, which allows us to control light within etched nanostructures. As semiconductor fabrication has matured so too has the crystal growth of quantum "boxes" for localizing electronic states in semiconductors. The combined engineering of electronic and optical "cavities" on the nanometer scale in semiconductors opens up several fruitful paths for advancing current and future technologies. The program is interested in the design, growth and fabrication of nanostructures that can serve as building blocks for nano-optical systems. The research goals include integration of nanocavity lasers, filters, waveguides, and diffractive optics, which can form nanofabricated photonic integrated circuits. Coupled to this area are optoelectronic solutions to enable practical quantum computing schemes.

In bridging the gap between electronics and photonics the program also explores opportunities in terahertz technologies. Diverse approaches have been taken to create THz sources and detectors over the 0.3 to 10 THz range. Desired are THz sources and detectors that are compact, efficient, solid-state devices capable of integration with other solid-state components. Integration of transmit and receive functions on the same chip is another goal. More specifically quantum well solutions are of highest interest.

This program supports Air Force requirements for information dominance by increasing capabilities in image capture; processing, storage, and transmission for surveillance; target discrimination; and autonomous navigation. In addition, high-bandwidth interconnects enhance performance of distributed processor computations that provide real-time simulation, visualization, and battle management environments.

Dr. Gernot Pomrenke AFOSR/NE (703) 696-8426  
DSN 426-8426 FAX (703) 696-8481  
E-Mail: [gernot.pomrenke@afosr.af.mil](mailto:gernot.pomrenke@afosr.af.mil)

### **Laser and Optical Physics**

Laser and optical physics research explores new ideas, knowledge, and insights in selected aspects and applications of these areas. Novel lasers and laser arrays, as well as nonlinear optical devices and phenomena are of interest. Application studies of microstructured optical fibers are ongoing and would be considered for expansion if funds are available. High brightness, narrow spectrum incoherent sources and arrays are also of interest directly for applications as well as for laser pumping. Ultrafast lasers and their applications are of interest, particularly small, lightweight, inexpensive, and high repetition rate sources, and applications to

materials processing and diagnostic imaging. Semiconductor laser arrays are being intensively investigated, together with associated optics, in the mid-infrared, in support of ongoing important Air Force development programs. Directed energy beams, particularly laser beams, are being explored in direct-write materials-processing techniques that offer broad and extremely important new capabilities, particularly in microelectronics and micromechanics fabrication and packaging, particularly for space. Adaptive optical devices and techniques are of interest, including large and micro-optical adaptive mirrors and mirror arrays, especially for space applications. Novel sources of monochromatic x-rays will be considered, particularly relatively small ones.

Dr. Howard R. Schlossberg AFOSR/NE (703) 696-7549

DSN 426-7549 FAX (703) 696-8481

E-Mail: [howard.schlossberg@afosr.af.mil](mailto:howard.schlossberg@afosr.af.mil)

### **Quantum Electronic Solids**

This program focuses on materials that exhibit cooperative quantum electronic behavior, with the primary emphasis on superconductors, and on any conducting materials with surfaces that can be modified and observed through the use of scanning tunneling and related atomic-force microscopies, the ultimate goal being the creation of new nano-devices. The program also focuses on device concepts using these materials for dense non-volatile memory elements, electromagnetic detection and signal processing in Air Force systems. The long-standing materials aspects of this program are based on the fabrication, characterization, and electronic behavior of thin and thick superconducting films that ultimately can lead to the production of new and improved electronic circuit elements and high-current-carrying cables. The major focus of the program is on coated conductors to be used in producing tapes that will be formed into cables in power applications. Secondary objectives are to understand the mechanisms that give rise to superconductivity in selected ceramics and to produce high-quality Josephson tunneling structures. A continuing interest in this program is the search for new electronic device concepts that involve superconductive elements, either alone or in concert with semiconductors and normal metals. New fabrication techniques for the generation of LSI of ceramic Josephson junctions are likewise of interest. Discovery of practical higher-temperature superconducting materials remains an important goal.

A growing aspect of this program is the inclusion of scanning probe and other techniques to fabricate, characterize, and manipulate atomic-, molecular-, and nanometer-scale structures (including carbon and other elemental nanotubes), with the aim of producing a new generation of improved sensors and non-volatile, ultra-dense memory, resulting in the ultimate miniaturization of analog and digital circuitry. This program element includes the use of polarized electrons to produce nuclear magnetic polarization as a basis for dense, non-volatile memory, with possible application to quantum computing at room temperature.

An important recent addition to this program features the investigation of so-called “left-handed materials” (also characterized as negative-index materials) and how to utilize them to produce compact and efficient circuit elements for aerospace communications and surveillance systems.

Finally, there is a continuing interest in the development of new (soft and hard) magnetic materials with high energy products at elevated temperatures to aid in providing power devices, switches and bearings for a new generation of more-electric aircraft that dispenses with hydraulics.

Dr. Harold Weinstock AFOSR/NE (703) 696-8572  
DSN 426-8572 FAX (703) 696-8481  
E-Mail: [harold.weinstock@afosr.af.mil](mailto:harold.weinstock@afosr.af.mil)

## **Semiconductor Materials**

This research area is directed toward developing advanced optoelectronic and electronic materials and structures to provide improvements required for future Air Force systems. The focus is currently on growth and use of semiconductors in bulk structures, single heterostructures, quantum wells, superlattices, quantum wires, and quantum dots. Proposals are sought for significant advances in these areas, or expansion to novel application of materials such as organic polymers, amorphous, and polycrystalline materials, with estimates comparing potential improvements to present capabilities and the impact on Air Force capabilities. Wavelength ranges of interest span the spectrum from UV, visible, NIR, MWIR, FIR, and extending into the terahertz range.

Novel fabrication methods, in-situ and ex-situ characterization methods, and innovative substrates and materials that increase the integration density, or fill factor and efficiency are of significant interest, as are device structures that integrate cooling, or exploit designs that avoid heating. Nonlinear optics is another area of interest for increasing laser power at desired wavelengths, and protection from directed energy threats. Advanced optoelectronic and electronic materials will provide the building blocks for advances in laser and sensor applications and related components.

Compound semiconductors, heterostructures and other such materials are the foundation of new generations of wavelength-diverse, high sensitivity detectors, and lower power consumption, high-efficiency electric lasers, as well as high efficiency multijunction solar cells. These materials provide the properties necessary for improved space situational awareness, National and Theatre Missile Defense (NMD/TMD) capabilities, and space asset protection to support Space Control, and theater missile surveillance, threat warning and tracking, chemical and biological agent detection, improved satellite communications, and environmental monitoring as part of Space Force Enhancement. Innovative approaches are sought for lasers to provide, or advance, capabilities such as aircraft infrared countermeasures, laser communications, laser radar for precision guided munitions, illumination, chemical/biological agent detection, missile warning, sensor jamming, and laser array pumping. Innovative approaches are sought for sensors for applications such as target and background phenomenology characterization, threat identification, warning, and tracking, and protection of aerospace vehicles from electro-optic, infrared guided threats. Materials are needed to provide survivability to aircrews, sensor systems, aircraft, and space systems from directed energy threats.

Also of interest are the semiconductor systems that exhibit ferromagnetism, which may lead to semiconductor spintronic devices. An understanding of these materials is important to device development.

Dr. Anne Matsuura AFOSR/NE (703) 696-6204  
DSN 426-6204 FAX (703) 696-8481  
E-Mail: [anne.matsuura@afosr.af.mil](mailto:anne.matsuura@afosr.af.mil)

## **Sensors in the Space Environment**

We are interested in the interaction of Air Force systems and sensors with the space environment. In target detection, navigation, or communication, the intervening medium and the background become an integral part of the sensor system. Often the sensors themselves are affected by exposure to the space environment. The space environment can also actively participate in spacecraft electrodynamics. The goal is to understand how naturally occurring and artificial environmental phenomena influence the performance of systems and sensors, and to take advantage of the space environment to maximize their performance. The exploitation of the space environment requires a fundamental understanding of the physics of space, and of how the environment affects and is affected by electronic and mechanical systems.

New developments in Air Force systems for satellites and aircraft are requiring new approaches to the study of their environment. New spacecraft power and propulsion systems will take advantage of the environment as an energy source as well as for navigation. Innovative solutions to intra-satellite communication and ranging may include free-space laser links or terahertz propagation through structured or turbulent plasma at the poles or equator. New optical communication and identification techniques will drive the study of atmospheric turbulence and of atmospheric absorption and emissions. A more thorough understanding of expected energetic particle fluxes and electromagnetic radiation will be required as nano-scale electronics are included in spacecraft systems. Optoelectronic circuitry and memory will facilitate the storage and transmission of data sets that are orders of magnitude larger than current system capabilities and will require high speed and error free communication links through the intervening medium.

Research goals include, but are not limited to, characterization and understanding of the geospace environment as it relates to sensors and systems; development of active experiments to probe and exploit the space environment, specification, and prediction of the effects of terrestrial and space backgrounds and radiation on sensor performance; and understanding the electromagnetic characteristics of the environment to insure secure, wide bandwidth communication through the atmosphere and ionosphere as well as between satellites.

Dr. Kent Miller AFOSR/NE (703) 696-8573  
DSN 426-8573 FAX (703) 696-8481  
E-mail: [kent.miller@afosr.af.mil](mailto:kent.miller@afosr.af.mil)

## **High Density Optical Memory**

There is a growing need within the Air Force for more and better computer data storage to support next generation processor architectures and new multi-media application software. This program thrust explores optical memory technologies that support page-oriented or holographic configurations in two or three dimensions. Capabilities of persistent spectral hole-burning systems for memory as well as for processing anchor this thrust. The spatio-spectral attributes of this technology link "free-space" interconnect concepts to those of multispectral systems. Devices are being developed that emit, modulate, transmit, filter, switch, and detect multispectral signals, for both parallel interconnects and quasi-serial transmission. It is important to develop the capability to buffer, store, and retrieve data at the rates and in the

quantity anticipated by these devices.

Atomic and molecular absorption of light within semiconductor and optoelectronic materials is the basis for the technologies in the homogeneously broadened, generally cryogenic, optically resonant materials that support the memory development. Understanding the fundamental interaction of light with matter is important for achieving these characteristics. Architectural problems are also of interest that include, but are not limited to, optical access and storage in memory devices to obviate capacity, access latency, and input/output bandwidth concerns.

This program supports Air Force requirements for information dominance by increasing capabilities in image capture; storage, and processing for surveillance; target discrimination; and autonomous navigation. Further important considerations for this program are the airborne and space environment in which there is a need to record, read, and change digital data at extremely high speeds.

Dr. Gernot Pomrenke AFOSR/NE (703) 696-8426  
DSN 426-8426 FAX (703) 696-8481  
E-Mail: [gernot.pomrenke@afosr.af.mil](mailto:gernot.pomrenke@afosr.af.mil)